**Division III Brown Bag Discussion (2/4/14)**

Test of Scientific Literacy Skills (TOSLS)—Gormally, Brickman, and Lutz (2012)

Categories of scientific literacy skills

1. Understand methods of inquiry that lead to scientific knowledge
2. Identify a valid scientific argument
3. Evaluate the validity of sources
4. Evaluate the use and misuse of scientific information
5. Understand elements of research design and how they impact scientific findings/conclusions
6. Organize, analyze, and interpret quantitative data and scientific information
7. Create graphical representations of data
8. Read and interpret graphical representations of data
9. Solve problems using quantitative skills, including probability and statistics
10. Understand and interpret basic statistics
11. Justify inferences, predictions, and conclusions based on quantitative data

Sample question:

4. Which of the following research studies is least likely to contain a confounding factor (variable that provides an alternative explanation for results) in its design?

a. Researchers randomly assign participants to experimental and control groups. Females make up 35% of the experimental group and 75% of the control group.

b. To explore trends in the spiritual/religious beliefs of students attending U.S. universities, researchers survey a random selection of 500 freshmen at a small private university in the South.

c. To evaluate the effect of a new diet program, researchers compare weight loss between

participants randomly assigned to treatment (diet) and control (no diet) groups, while controlling for average daily exercise and pre-diet weight.

d. Researchers tested the effectiveness of a new tree fertilizer on 10,000 saplings. Saplings in the control group (no fertilizer) were tested in the fall, whereas the treatment group (fertilizer) were tested the following spring.

Science Literacy Concept Inventory (SLCI)—Nuhfer and colleagues

Outcomes for Science Literacy

Students will be able to…

1. Define the domain of science and determine whether a statement constitutes a hypothesis that can be resolved within that domain.

2. Describe through example how science literacy is important in everyday life to an educated person.

3. Explain why the attribute of doubt has value in science.

4. Explain how scientists select which among several competing working hypotheses best explains a physical phenomenon.

5. Explain how "theory" as used and understood in science differs from "theory "as commonly used and understood by the general public.

6. Explain why peer review generally improves our quality of knowing within science.

7. Explain how science employs the method of reproducible experiments to understand and explain the physical world.

8. Articulate how science’s way of knowing rests on some assumptions.

9. Distinguish between science and technology by examples of how these are different frameworks of reasoning.

10. Cite a single major theory from one of the science disciplines and explain its historical development.

11. Explain and provide an example of how modeling is used in science.

12. Explain why ethical decision-making becomes increasingly important to a society as it becomes increasingly advanced in science.

Sample question:

Which of the following statements presents a hypothesis that science can now easily resolve?

1. Warts can be cured by holding quartz crystals on them daily for a week.
2. A classmate sitting in the room can see the auras of other students.
3. Radio City Music Hall in New York is haunted by several spirits.
4. People with chronic illnesses have them as a punishment for past misdeeds.

**Examples of S M Learning Goals**

Humboldt State

Lower division science GE outcomes

* Apply scientific concepts and theories to develop scientific explanations of natural phenomena.
* Critically evaluate conclusions drawn from a particular set of observations or experiments.
* Demonstrate their understanding of the science field under study through proper use of the technical/scientific language, and the development, interpretation, and application of concepts.

St. Olaf

Scientific Exploration and Discovery Requirement

* Knowledge of scientific content and scientific principles in a disciplinary or interdisciplinary field within the natural sciences.
* Proficiency in the application of the scientific method, including the appropriate collection, analysis, and interpretation of data, and effective communication of findings.
* An ability to use scientific terminology appropriately in meaningful scientific dialogue.
* An understanding of the process of science as an intellectual pursuit and of the ways in which scientific ideas evolve and come to be accepted.

Knox College

**Natural and Physical Sciences** (Courses in this area lie in the physical or biological sciences that include an experimental component.) The goals of an NPS foundation course are:

1. Students will be able to identify key concepts used in understanding the physical or biological world using a scientific discipline or framework.
2. Students will be able to describe important theories in the physical or biological sciences and the empirical evidence upon which they are based.
3. Students will be able to describe the application of the scientific method to questions using the following concepts: formulate and test a hypothesis, analyze data, draw conclusions.

**Quantitative and Symbolic Reasoning** (Courses in this area focus on methods of abstract or symbolic reasoning including mathematics, logic, algorithmic or statistical reasoning.) The goals of a QSR foundation course are:

1. Students will be able to translate between real world concepts and quantitative or symbolic abstract structures.
2. Students will be able to perform and interpret quantitative or symbolic manipulations in an abstract structure;
3. Students will be able to construct carefully reasoned logical arguments.
4. Students will be able to use abstract methods to analyze patterns and formulate conjectures with the goal of verifying them rigorously.

**Discipline Specific Learning Goals**

**Biology (Trinity)**

1. Biology majors will gain a broad background in the fundamental concepts of biology.  Students will:

* gain conceptual knowledge at the different levels of biological organization: cellular/molecular, organismal, and ecological.
* demonstrate a knowledge of form and function for at least  one major non-vertebrate group of living organisms.
* be able to compare and contrast features of living organisms that acknowledge a common origin while recognizing evolutionary differences.

2.  Biology majors will gain knowledge and experience in the basic methods, instrumentation and quantitative analytical skills used to conduct scientific research in biology.   Students will:

* be able to frame scientific questions or problems.
* investigate biological questions or problems experimentally, and be able to collect, analyze and interpret quantitative data.
* demonstrate an understanding of the process of science.
* receive training and engage in hands-on laboratory work using scientific equipment and methods.

3.   Biology majors will develop critical thinking and communication skills, and be able to convey biological information to professional scientists and the general public in both written and oral forms.   Students will:

* be able to communicate the results of scientific investigations orally and in writing.
* be able to evaluate scientific arguments critically.
* demonstrate critical thinking by successfully applying fundamental biological concepts to novel scenarios.

4.  Biology majors will develop intellectual independence, scientific literacy and an appreciation for the connections between biological science and society. Students will:

* acquire and understand information from published biological  literature.
* be able to apply scientific thinking to every day problems.
* appreciate the relevance of biology to society.

**Chemistry/Biochemistry (Trinity)**

Learning Goals

**1. Develop the ability to read and understand the primary chemical literature.**

**2. Develop research and analytical skills**

**3. Learn how to work both independently and cooperatively.**

**4. Learn how to communicate chemistry and biochemistry clearly, coherently and effectively using both written and oral expression.**

**5. Develop the ability to analyze data using mathematics.**

**6. Develop a knowledge and understanding of how chemicals and chemical processes can be handled safely.**

**7. Develop scientific literacy.**

**Biochemistry/Molecular Biology (Middlebury)**

Learning Goals for the Major

##### Students who successfully complete a major in Molecular Biology and Biochemistry will be able to:

* Describe basic biochemical and molecular biological concepts and principles
* Appreciate the different levels of biological organization, from molecules to organisms
* Understand that Molecular Biology has a chemical, physical, informational and mathematical basis
* Explain the importance of the scientific method to understanding natural phenomena
* Effectively communicate scientific data and ideas, both orally and in writing to a liberal arts audience
* Critically evaluate experimental data and primary papers, develop a hypothesis, and design experiments to address an interesting and novel problem
* Collaborate with other researchers
* Demonstrate advanced knowledge in a specialized field of biochemistry and molecular biology
* Demonstrate an awareness of ethical issues in the molecular life sciences
* Demonstrate the ability to think in an integrated manner and look at problems from different perspectives.

**Computer Science (Knox College)**

**Departmental Learning Goals**

Students completing a major in Computer Science will be able to:

1. Analyze problems from other disciplines and extract the computational elements of those problems
2. Design efficient solutions to computational problems
3. Develop new algorithms to solve computational problems, assess the complexity of the algorithm, and compare the algorithm to others in order to decide the best algorithm to use (from a set of algorithms) to solve a given problem
4. Explain their design using terminology of the field
5. Implement a design solution in a variety of programming languages
6. Understand the inner workings of computers and be able to use that understanding to impact the efficiency of their solutions of computational problems

**Geosciences (Colby College)**

For nearly two centuries, the Department of Geology has provided outstanding liberal arts educational opportunities for students at Colby College. Since its inception, the mission of the department has been to:

*-> provide an understanding of the inter-relationships between the Earth sciences and the human experience through varied approaches and technologies;   
-> emphasize practical problem-solving using data and modern analytical techniques drawn from diverse scientific disciplines, and communicate effectively the results to diverse audiences;   
-> develop interpersonal communication skills via interdisciplinary approaches that provide graduates with the tools necessary for successful transition into a global society; and   
-> promote a collaborative atmosphere of student-faculty engagement culminating in an original research experience.*

These learning goals have enabled geology students to achieve professional success both within the Earth sciences and in other career paths.

**Kinesiology Goals (Cornell College)**

Students are expected to:

* Be able to access and utilize information and ideas from inter-related academic disciplines for the study of motor, cognitive, and affective aspects human physical activity.
* Appreciate the role that a lifetime of physical activity plays in contributing to personal health and wellness and self-awareness.
* Understand physiological concepts related to structure and functioning of the human body during physical activity.
* Appreciate the various forms of physical activity as dynamic cultural and psycho-social phenomena.
* Be able to apply basic principles and procedures for safe and healthy physical activity and the prevention and treatment of athletic injuries.
* Understand principles of leadership and management as they apply to physical activity settings.

## Mathematics and Statistics (University of Maine)

## Learning Goals for Undergraduates -

* Develop a solid foundation of basic knowledge and techniques in the areas of mathematics and statistics.  This basic knowledge includes conceptual understanding of major theorems in the several branches of mathematics, facility with mathematical language and syntax, the ability to express mathematical ideas in clear grammatical English, the ability to formulate and analyze mathematical models of real world situations, and the ability to use a computer to carry out numerical and symbolic mathematical calculations.
* Understand connections among mathematical areas, between mathematics and applied areas, and between mathematics and topics in the liberal arts. Mathematics should be seen as an ongoing human enterprise pursued for both its practicality and its intrinsic beauty.

**Physics (Arizona State University)**

Mission and Learning Goals

The operation of ASU introductory physics laboratories is based on reaching the GOALS developed by American Association of Physics Teachers (see Appendix 1) and meeting the standards set for the New American University by the ASU administration. We hope that our lab courses offer students a fair opportunity to:

* verify in action some fundamental concepts of physics,
* develop independent critical and abstract thinking,
* build students analytical skills,
* improve students communication skills,
* appreciate the beauty and value of experimental work.

After completion of the physics lab classes our students should:

* have improved their understanding of physics,
* feel more confident in any experimental environment,
* be accustomed to a safe scientific conduct in laboratory setting,
* be familiar with techniques and modern technology used for data collection,
* be able to apply proper data analysis ,
* know the methods of reporting the experimental results accepted in scientific community.

**Psychology (St. Olaf)**

Intended Learning Outcomes

*Students will demonstrate:*

1. an understanding of natural and social science concepts in psychology, in the areas of developmental, experimental design, human learning and cognition, personality, physiological, psychopathology, sensation and perception, social, and statistics*.*
2. the ability to frame and explore questions in psychology by using appropriate resources to develop hypotheses, analyze data, and interpret results.
3. the ability to identify and think critically about psychology’s connections to other disciplines in the liberal arts.
4. the ability to apply psychological principles to explain behavior and test theoretical predictions using appropriate concepts, theories, and methods.
5. knowledge of the ethical principles guiding psychology by
   1. explaining why APA ethical principles are important,
   2. using those principles to evaluate others’ research, and
   3. incorporating those principles into their own empirical research

**What is Science Literacy?**

From the National Science Education Standards: “Scientific literacy is the knowledge and understanding of scientific concepts and processes required for personal decision making, participation in civic and cultural affairs, and economic productivity. It also includes specific types of abilities. In the National Science Education Standards, the content standards define scientific literacy.”

National Research Council (NRC) defines scientific literacy as the ability “use evidence and data to evaluate the quality of science information and arguments put forth by scientists and in the media”.

**Carol Brewer,** Associate Dean of the College of Arts and Sciences and biology professor at University of Montana, Missoula, says, “For me the definition of scientific literacy is being able to look at an article in a newspaper or in a magazine or listen to commentary on a newscast or on TV and be able to understand what is being talked about and also being able to be skeptical. It’s knowing enough about science to be able to judge if the story that you are being told is being told in a fair and accurate way.”

**Robert M. Hazen, Ph.D.**, a research scientist at the Carnegie Institution of Washington’s Geophysical Laboratory and Clarence Robinson Professor of Earth Science at George Mason University, Virginia, says “Scientific literacy, quite simply, is a mix of concepts, history, and philosophy that help you understand the scientific issues of our time.

* Scientific literacy is not the specialized, jargon-filled esoteric lingo of the experts. You don’t have to be able to synthesize new drugs to appreciate the importance of medical advances, nor do you need to be able to calculate the orbit of the space station to understand its role in space exploration.
* Scientific literacy is rooted in the most general scientific principles and broad knowledge of science; the scientifically literate citizen possesses facts and vocabulary sufficient to comprehend the context of the daily news.
* If you can understand scientific issues in magazines and newspapers (if you can tackle articles about genetic engineering or the ozone hole with the same ease that you would sports, politics, or the arts) then you are scientifically literate.”

From our Survey…

“Using science for everyday/life decision-making”